Answers, Even-Numbered Problems, Chapter 5

5.2. the tension in each string is *w (= mg)*.

5.4. **(a)** 2540 N
(b) The $\theta = 1.01°$.

5.8.
(a) $5.23 \times 10^4 \text{ N}$
(b) $3.36 \times 10^4 \text{ N}$

5.10. **(a)** The free-body diagram for the car is given in Figure 5.10. The vertical weight *w* and the tension *T* in the cable have each been replaced by their *x* and *y* components.
(b) 5460 N.
(c 7220 N

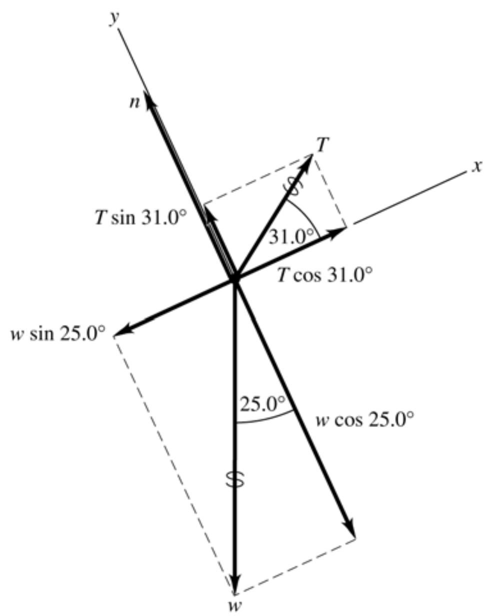

Figure 5.10

Figure 5.11a, b

5.12. **(a)** 84.9 N
(b) 60.0 N

5.14. **(a)** $T_1 = w \sin\alpha$.
(b) $T_2 = 2w \sin\alpha$.
(c) $n_A = n_B = w \cos\alpha$.

(d) For $\alpha \to 0$, $T_1 = T_2 \to 0$ and $n_A = n_B \to w$. For $\alpha \to 90°$, $T_1 = w$, $T_2 = 2w$ and $n_A = n_B = 0$.

5.16.

a) 3.96 m/s^2.
(b) 21.7 N.

5.18. **(a)** 2.08 m/s^2.
(b $T_A = 104 \text{ N}; \quad T_B = 62.4 \text{ N}$.

5.20. **(a)** 2.08 m/s^2. $\phi = 12.3°$.
(b) 1.59 m/s

5.22. **(a)** 160 m.
(b) 6000 N.

5.24. **(a)** 1.78 m/s^2. downward
(b) 2.14 m/s^2.
(c) $n = 0$ means $a_y = -g$. The student should worry; the elevator is in free-fall.
(d) In part (a), 6820 N.
In part (c), $T = 0$.

5.26. **(a)** $A = 1.50 \text{ m/s}^2$. $B = 0.50 \text{ m/s}^3$.
(b) At, 5.50 m/s^2.
(c). $1.56w = 1.56\ mg$.
(d) $2.87 \times 10^4 \text{ N}$

5.28. **(a)** The friction is static for $P = 0$ to $P = 75.0 \text{ N}$. The friction is kinetic for $P > 75.0 \text{ N}$.
(b $\mu_s = 0.556$.. $\mu_k = 0.370$.
(c) When the block is moving the friction is kinetic and has the constant value $f_k = \mu_k n$, independent of *P*. This is why the graph is horizontal for $P > 75.0 \text{ N}$. When the block is at rest, $f_s = P$ since this prevents relative motion. This is why the graph for $P < 75.0 \text{ N}$ has slope $+1$.

5.30. **(a)** If there is no applied force, no friction force is needed to keep the box at rest.
(b) $f_s = 6.0 \text{ N}$ in the opposite direction.

(c) 16.0 N.
(d) $8.0\ \mathrm{N}$ is required to keep it moving at constant velocity.

5.32 $\mu_{\mathrm{k}} = 0.25.$

5.34. **(a)** $54.0\ \mathrm{m}$.
(b) $16.3\ \mathrm{m/s}$

5.36 **(a)** $\mu_{\mathrm{k}} = 0.556$.
(b) $-2.13\ \mathrm{m/s^2}$. The acceleration is upward and block *B* slows down.

5.38
Low pressure, 0.0259.
High pressure, 0.00505.

5.40 $230\ \mathrm{N}$.

5.42 **(a)** $19.3°$.
(b) $0.92\ \mathrm{m/s^2}$.
(c) $3\ \mathrm{m/s}$.

5.44 **(a)** $F = \dfrac{\mu_{\mathrm{k}} mg}{\cos\theta + \mu_{\mathrm{k}} \sin\theta}$
(b) $290\ \mathrm{N}$.

5.48. **(a)** (5/4)g, down.
(b) (3/4)g, down.

5.50. **(a)** 0.290
(b), . $14.4\ \mathrm{m/s}$.

5.52 **(a)** $6.19\ \mathrm{s}$.
(b) No

5.54. **(a)** $0.269.$
(b) $0.067\ \mathrm{m}$.

5.56 **(a)** $5.24\ \mathrm{m/s}$.
(b) $833\ \mathrm{N}$; $931\ \mathrm{N}$.
(c) $14.2\ \mathrm{s}$

(d) $2mg = 1760\ \text{N}$, twice his true weight.

5.58. **(a)** $230\ \text{m}$.
(b) $2450\ \text{N}$

5.60 **(a)** $4.64\ \text{m/s}^2$, upward.
(b) $105\ \text{N}$

5.62
The tension in the lower chain is equal to *w*.
the tension in the rope, $w/2$. T
the tension in the upper chain is also *w*.

5.64. $T(x) = F\left(1 - \frac{mx}{L(M+m)}\right)$

5.66.
(a) $12.0\ \text{N}$

(b $15.0\ \text{N}$

5.68.
(a) $16.9\ \text{N}$
(b) $10.1\ \text{N}$

5.70 **(a)** $5.72 \times 10^5 \text{N}$.
(b) $4170\ \text{m}$.

5.72. $5.0\ \text{m/s}$.

5.74. $2.8\ \text{m/s}^2$.

5.76 **(a** $64.6\ \text{m},$ which is greater than 40 m. You don't stop before you reach the hole, so you fall into it.
(b). $16\ \text{m/s}$.

5.78. The fraction that hangs over is $\frac{\mu_s}{1+\mu_s}$.

5.80. $29.3\ \text{m/s} = 65.5\ \text{mi/h}$. He was guilty.

5.82. $2.221\ \text{s}$. In this time, the truck moves $5.43\ \text{m}$

5.84. The time it takes to reach the ground is 12.4 s

The vertical component of the PAPS force is 1450 N
The horizontal component is 400 N,

5.86. **(a)** the blocks will slide to the left;

(b) $a = 0.067g = 0.658 \text{ m/s}^2$.

(c) 424 N.

5.88. . 39.0 kg.

5.90. 105 N.

5.92. **(a)** the blocks will have the same acceleration, 2.21 m/s^2.

(b) 2.27 N.

(c) The string will be slack. The 4.00-kg block will have $a = 2.78 \text{ m/s}^2$ and the 8.00-kg block will have $a = 1.93 \text{ m/s}^2$, until the 4.00-kg block overtakes the 8.00-kg block and collides with it.

5.94. **(a)** $\tan\theta = a / g$.
(b) $\theta = 9.46°$.
(c) $45°$.

5.96. (a) 21 m/s.
(b) 8.5 m/s.
.

5.98. 16.8 m/s, about 60.6 km/h.

5.100. $v(t) = 2v_t\left[\frac{1}{2} + e^{-(k/m)t}\right]$.

5.102. (a) $v = v_0 - \frac{v_0^{1/2}kt}{m} + \frac{k^2t^2}{4m^2}$; $x = v_0t - \frac{v_0^{1/2}kt^2}{2m} + \frac{k^2t^3}{12m^2}$.

(b) $t = \frac{2mv_0^{1/2}}{k}$.

(c) $x = \frac{2mv_0^{3/2}}{3k}$

.

5.104. **(a)**. $31.0\ \text{N}$.

(b). $3.53\ \text{m/s}$. The number of revolutions per second is

$$\frac{v}{2\pi r} = \frac{3.53\ \text{m/s}}{2\pi(0.75\ \text{m})} = 0.749\ \text{rev/s} = 44.9\ \text{rev/min}.$$

(c) $29.9\ \text{rev/min}$

5.106. **(a)** $1.84\ \text{m}$; $0.61\ \text{s}$.

(b) $0.26\ \text{m}$.

5.108. **(a)** $434\ \text{N}$.

(b) $19.8\ \text{m/s}$. The answer doesn't depend on the cart's mass, because the centripetal force needed to hold it on the road is proportional to its mass and so to its weight, which provides the centripetal force in this situation.

5.110. **(a)** $\theta = 77.3^\circ$ above the horizontal. The magnitude of the net force exerted by the seat $854\ \text{N}$

(b) The magnitude of the force is the same, but the horizontal component is reversed.

5.112. **(a)** $11.3\ \text{m/s}$.

(b) The $5390\ \text{N}$

5.114. $v = \sqrt{gr\,M/m}.$

5.116. $F_x = -(1.58\ \text{N/s})t$ and $F_y = -4.40\ \text{N}$.

(b) The graph is given in Figure 5.116.

(c) $6.48\ \text{N}$ at an angle of 223°.

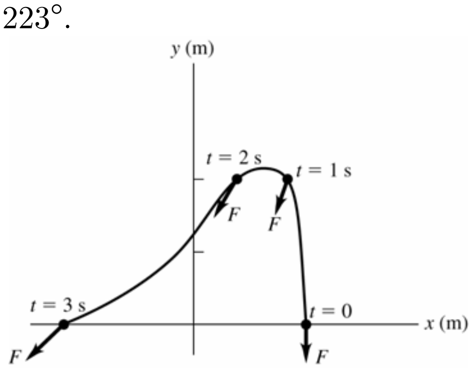

Figure 5.116

5.118. **(a)** $F_A = 61.8\ \text{N}$.

(b) $F_B = -30.4\ \text{N.}$, where the minus sign indicates that the track pushes *down* on the car.

5.120. (a)

$$A = \frac{-gm}{(M+m)\ \tan\alpha + (M/\tan\alpha)}$$

$$a_x = \frac{gM}{(M+m)\ \tan\alpha + (M/\tan\alpha)}$$

$$a_y = \frac{-g(M+\text{m})\ \ \tan\alpha}{(M+m)\ \tan\alpha + (M/\tan\alpha)}$$

(b) When $M >> m, A \to 0,$ as expected (the large block won't move). Also,

$a_x \to \dfrac{g}{\tan\ \ \alpha + (1/\tan\alpha)} = g\dfrac{\tan\ \ \alpha}{\tan^2\alpha + 1} = g\sin\alpha\cos\alpha$ which is the acceleration of the block ($g\sin\alpha$ in this case), with the factor of $\cos\alpha$ giving the horizontal component. Similarly, $a_y \to -g\sin^2\alpha$.

(c) The trajectory is a spiral.

5.122. IDENTIFY: Apply $\sum \vec{\text{F}} = m\vec{\text{a}}$.

SET UP: Let $+x$ be directed up the ramp.

EXECUTE: The normal force that the ramp exerts on the box will be $n = w\cos\alpha - T\sin\alpha$. The rope provides a force of $T\cos\theta$ up the ramp, and the component of the weight down the ramp is $w\sin\alpha$. Thus, the net force up the ramp is

$$F = T\cos\theta - w\sin\alpha - \mu_{\text{k}}(w\cos\alpha - T\sin\theta) = T(\cos\theta + \mu_{\text{k}}\sin\theta) - w(\sin\alpha + \mu_{\text{k}}\cos\alpha)$$

The acceleration will be the greatest when the first term in parentheses is greatest and this occurs when $\tan\theta = \mu_{\text{k}}$.

EVALUATE: Small θ means *F* is more nearly in the direction of the motion. But $\theta \to 90°$ means *F* is directed to reduce the normal force and thereby reduce friction. The optimum value of θ is somewhere in between and depends on μ_{k}. When $\mu_{\text{k}} = 0$, the optimum value of θ is $\theta = 0°$.

5.124. (a) The free-body diagram for the falling ball is sketched in Figure 5.124.

(b) Newton's Second Law is then $ma = mg - Dv^2$. Initially, when $v = 0,$ the acceleration is *g*, and the speed increases. As the speed increases, the resistive force increases and hence the acceleration decreases. This continues as the speed approaches the terminal speed.

(c) At terminal velocity, $a = 0,$ so $v_{\text{t}} = \sqrt{\dfrac{mg}{D}}$ in agreement with Eq. (5.13).

(d) The equation of motion may be rewritten as $\frac{dv}{dt} = \frac{g}{v_{\mathrm{t}}^2}(v_{\mathrm{t}}^2 - v^2)$. This is a separable equation and may be expressed as $\int \frac{dv}{v_{\mathrm{t}}^2 - v^2} = \frac{g}{v_{\mathrm{t}}^2} \int dt$ or $\frac{1}{v_{\mathrm{t}}} \ \mathrm{arctanh}\left(\frac{v}{v_{\mathrm{t}}}\right) = \frac{gt}{v_{\mathrm{t}}^2}$.
$v = v_{\mathrm{t}} \ \tanh\left(gt/v_{\mathrm{t}}\right)$.

5.126. (a) $F/2 = 62 \ \mathrm{N}$, which is insufficient to raise either block; $a_1 = a_2 = 0$.

(b) $F/2 = 147 \ \mathrm{N}$. The larger block (of weight 196 N) will not move, so $a_1 = 0$, but the smaller block, of weight 98 N, has a net upward force of 49 N applied to it, and so will accelerate upwards with $a_2 = \frac{49 \ \mathrm{N}}{10.0 \ \mathrm{kg}} = 4.9 \ \mathrm{m/s^2}$.

(c) $F/2 = 212 \ \mathrm{N}$, so the net upward force on block *A* is 16 N and that on block *B* is 114 N, so $a_1 = \frac{16 \ \mathrm{N}}{20.0 \ \mathrm{kg}} = 0.8 \ \mathrm{m/s^2}$ and $a_2 = \frac{114 \ \mathrm{N}}{10.0 \ \mathrm{kg}} = 11.4 \ \mathrm{m/s^2}$.